

# **INDOOR AIR QUALITY ASSESSMENT**

**Weymouth High School  
360 Pleasant Street  
Weymouth, Massachusetts**



Prepared by:  
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Bureau of Environmental Health Assessment  
Emergency Response/Indoor Air Quality Program  
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## **Background/Introduction**

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Weymouth High School (WHS), 360 Pleasant Street, Weymouth, MA. On November 26, 2003, Cory Holmes, an Environmental Analyst for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of this building. Concerns about indoor air quality related to construction activity prompted the request.

The WHS is a three-story red brick structure that was built in the late 1960's/early 1970's. A new addition (scheduled for completion in July 2004) was under construction on the south side of the school at the time of the assessment. No construction was being conducted in the occupied section of the school at the time of the assessment. To help limit entrainment of construction generated dust, school officials reported that changing of ventilation equipment filters was increased from three to five times a year during construction.

## **Methods**

BEHA staff conducted air tests for carbon dioxide, carbon monoxide (CO), temperature and relative humidity with the TSI, Q-Trak, IAQ Monitor Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series, Photo Ionization Detector (PID). Air tests for ultrafine particulates (UFPs) were taken with the TSI, P-Trak™ Ultrafine Particle Counter Model 8525. Air testing was conducted in exterior rooms directly impacted by construction activities. Several interior rooms, not directly affected by construction were tested for comparison.

## Results

The school houses approximately 1,400 students in grades 9-12 and also has a staff of approximately 160. Tests were taken during normal operations at the school and results appear in Table 1.

## Discussion

### Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in ten of fifteen areas surveyed, indicating inadequate air exchange in a number of areas. Fresh air in exterior classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Obstructions to airflow, such as papers and books were seen on univents in classrooms. In order for univents to provide fresh air as designed, intakes must remain free of obstructions.

Exhaust ventilation in exterior classrooms is provided by ducted, grated wall vents. No draw of air was detected in several classrooms, which can indicate that exhaust ventilation was turned off, or that rooftop motors are not functioning. In addition, a number of these vents were blocked by desks and other items (Picture 2). As with the univents, in order for exhaust ventilation to function as designed, they must remain free of obstructions. Importantly, these vents must be activated. Without proper exhaust ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints.

The mechanical supply and exhaust ventilation system for interior classrooms consists of grated, wall or ceiling-mounted vents. These supply and exhaust vents are ducted to rooftop motors (Pictures 3 and 4). This system was operating during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult [Appendix A](#).

Temperature measurements ranged from 61° F to 79° F, which were outside the BEHA comfort guidelines in a number of areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Occupants expressed a number of temperature control/comfort complaints, particularly excessive heat from classroom univents. In an effort to reduce temperature, occupants opened windows. However, cold air introduced through windows triggers thermostats to call for *more heat*. Opened windows enhance temperature control difficulties. It is also difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents and exhaust vents obstructed/not operating). In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements in the building ranged from 24 to 51 percent, which were below the BEHA recommended comfort range in some areas. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative

humidity is a very common problem during the heating season in the northeast part of the United States.

## **Renovations**

It is important to note that the Massachusetts Department of Education (MDOE) amended their regulations in 1999 to address concerns associated with school renovation projects in Massachusetts (MDOE, 1999). Renovation activities can produce a number of pollutants, such as volatile organic compounds (VOCs) found in paints, mastics and other materials, which are carbon-based chemicals that evaporate rapidly, causing eye, nose and respiratory irritation. No increased levels of TVOCs over background levels were measured in occupied areas of the school during the assessment. Other pollutants may include dirt, dust, particulates, and combustion products, such as carbon monoxide from construction vehicles. Particles generated from construction activities can settle on horizontal surfaces in classrooms. Dusts can be irritating to the eyes, nose and respiratory tract.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within the rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an

eight-hour average. Outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). Measurable levels of carbon monoxide below the NAAQS and MDPH corrective action level were detected in some areas of the school. Detection of CO within the school environment indicates that potential pathways for construction-generated pollutants to enter the building exist. The most likely pathways identified were univent air intakes, open windows and breaches in/around construction barriers. *Carbon monoxide should not be present in a typical, indoor environment.* If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels.

The combustion of fossil fuels, welding, steel cutting, concrete/brick boring and other renovation activities can produce particulate matter that is of a small diameter ( $<10\text{ }\mu\text{m}$ ) (UFPs), which can penetrate into the lungs and subsequently cause irritation. For this reason a device that can measure particles of a diameter of  $10\text{ }\mu\text{m}$  or less was used to identify pollutant pathways from the renovation site into occupied areas.

BEHA staffed conducts air monitoring for UFPs by using an instrument, the TSI P-Trak<sup>TM</sup> Ultrafine Particle Counter Model 8525, to count the number of particles that are suspended in a cubic centimeter ( $\text{cm}^3$ ) of air. This type of air monitoring is useful for tracking and identifying the source of airborne pollutants by counting the actual number of airborne particles. The source of particle production can be identified by moving the UFP counter through a building towards the highest measured concentration of airborne particles. Measured levels of particles/ $\text{cm}^3$  of air increase as the UFP counter is moved closer to the source of particle production. While this equipment can ascertain whether unusual sources of ultrafine particles exist in a building or whether particles are penetrating through spaces in doors or walls, it cannot be used to quantify

exposure levels. The primary purpose of these tests at the school is *identifying and reducing/preventing pollutant pathways*.

Air monitoring for UFPs was conducted in areas that may be directly impacted due to close proximity to renovation sites, including classrooms and hallways. For comparison (i.e. background), UFPs measurements were taken indoors, in areas away from renovation sites, as well as outdoors were taken. Increased levels of UFPs over background levels were measured around construction barriers, in main hallways near construction barriers and in classrooms in close proximity to the construction site (Table 1). During the assessment, concrete was being poured in an area directly adjacent to the occupied building. Concrete preparation and pouring requires the operation of a number of vehicles (Picture 5), including a cement mixer. Welding was also being conducted outside of occupied classrooms (Picture 6). Closer scrutiny revealed that construction barriers were not sealed. Strong drafts were detected around construction barriers on both the first and second floors (Pictures 7-10). The second floor barrier had several holes in it, from which drafts could be felt. Strong drafts were also felt from missing ceiling tiles near construction barriers (Picture 9), which serve as a means for construction-generated pollutants to enter occupied areas. Dust and debris can move with drafts from the construction zone to occupied areas (Figure 2).

As discussed, a number of construction vehicles and several large piles of dirt/construction debris were observed around the perimeter of the building. This activity should be closely monitored to avoid the entrainment of vehicle exhaust and other construction generated pollutants inside the building via open doors or windows (Pictures 5 and 11). A number of classrooms adjacent to the construction zone had open windows. The opening of

windows allows for unfiltered air to enter the classroom environment carrying with it airborne dirt, dust and particulates. Dusts can be irritating to the eyes, nose and respiratory tract.

### **Other Concerns**

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated from windowsills adjacent to the construction site and/or cleaned periodically to avoid excessive dust build up. A number of supply and return vents in classrooms (e.g. classroom 109), common areas and in restrooms had accumulated dust (Picture 12).

### **Conclusions/Recommendations**

A number of pathways exist for pollutants to move from areas under construction into occupied spaces. These pathways indicate that the containment measures at the time of the assessment were not sufficient to contain pollutants related to construction work. The following recommendations should be implemented in order to reduce the migration of construction-generated pollutants into occupied areas and their potential impact on indoor air quality:

1. Comply with 603 CMR 38.00: School Construction – Massachusetts Department of Education. This regulation states that “[a]pplicants shall implement containment procedures for dusts, gases, fumes, and other pollutants created during renovations/construction as part of any planned construction, addition to, or renovation of a

school if the building is occupied by students, teachers or school department staff while such renovation and construction is occurring. Such containment procedures shall be consistent with the most current edition of the IAQ Guidelines for Occupied Buildings Under Construction published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA). All bids received for school construction or renovations shall include the cost of planning and execution of containment of construction/renovation pollutants consistent with the SMACNA guidelines [608 CMR 38.03(13)] General Requirements: Capital Construction” (MDOE, 1999).

2. Properly seal construction barriers with polyethylene plastic sheeting and duct tape. Consider creating dual barriers by installing polyethylene on both sides of the barrier. Seal holes created by missing tiles in ceilings. Inspect these areas regularly (e.g., daily) for integrity as remediation efforts progress.
3. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.
4. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.
5. Schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy, when possible.
6. Cover dirt/debris piles with tarps or wet down to decrease aerosolization of particulates, when possible.

7. Notify faculty of construction activities, as renovations may be conducted in close proximity to their classrooms. In certain cases, classrooms adjacent to construction activities may need to have their HVAC equipment deactivated and windows closed periodically to prevent unfiltered air and vehicle exhaust from entering the building. For this reason, prior notification(s) should be made.
8. Disseminate scheduling itinerary to all affected parties via meetings, newsletters or weekly bulletins.
9. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).
10. Consult MSDS' for any material applied to the effected area during construction including any sealant, adhesives, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.
11. Relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of construction/renovations, if possible.
12. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider increasing manpower or work hours (e.g., before school) to accommodate increase in dirt, dust accumulation due to construction activities. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner in conjunction with wet wiping/mopping of all surfaces is recommended.

13. Consider mounting a filter medium on the exterior of univent air intakes to minimize entrainment of construction generated dust and debris. Continue to change HVAC filters more regularly in areas impacted by renovation activities.

### **General Indoor Air Quality Recommendations**

1. Operate both supply and exhaust ventilation continuously during periods of school occupancy independent of classroom thermostat control to maximize air exchange.
2. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Operate fresh air supply univents while classrooms are occupied. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
3. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
4. Remove all blockages from univents and exhaust vents.
5. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
6. Repair and/or replace thermostats as necessary to maintain comfort.
7. Develop a clear line of communication between the central maintenance department and school personnel for prompt remediation of temperature and/or ventilation concerns/complaints. This can be done by establishing a written request system administered by a single responsible person. Classroom occupants should report

temperature extremes immediately to school administration/maintenance and refrain from deactivating/obstructing equipment.

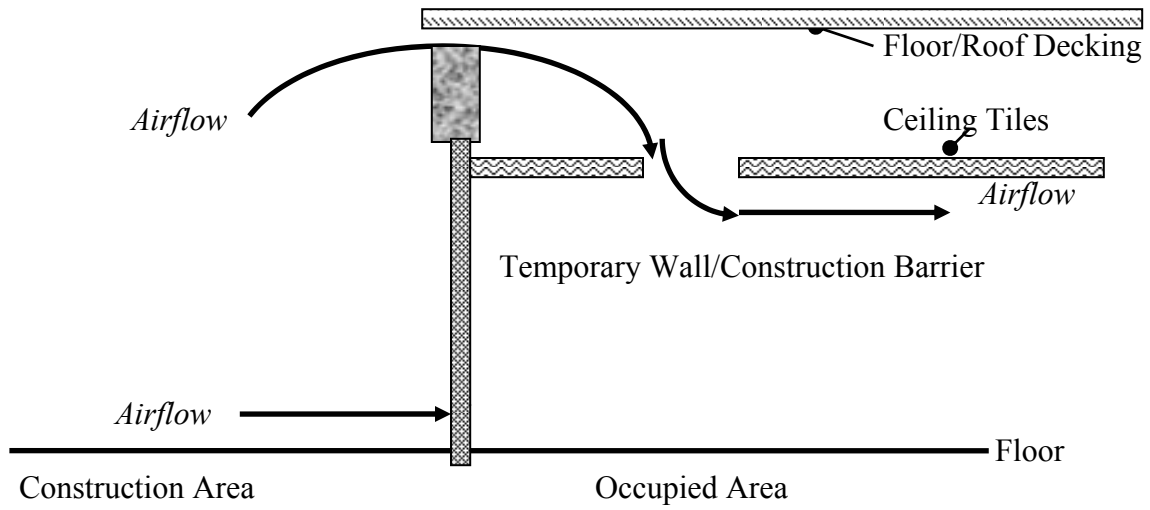
8. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
9. Clean supply and exhaust vents periodically to prevent excessive dust build-up.
10. Consider adopting the US EPA document, “Tools for Schools” in order to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
11. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website at <http://www.state.ma.us/dph/beha/iaq/iaqhome.htm>.

## References

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- SMACNA. 1994. HVAC Systems Commissioning Manual. 1<sup>st</sup> ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.
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<http://www.epa.gov/air/criteria.html>.

**Figure 2**

**Airflow From Construction Area Through Missing Ceiling Tiles**



**Picture 1**



**Classroom Univent**

**Picture 2**



**Classroom Exhaust Vent Obstructed by Furniture**

**Picture 3**



**Interior Classroom Supply Vent**

**Picture 4**



**Interior Classroom Return/Exhaust Vent**

**Picture 5**



**Construction Vehicles Adjacent to the Occupied Building**

**Picture 6**



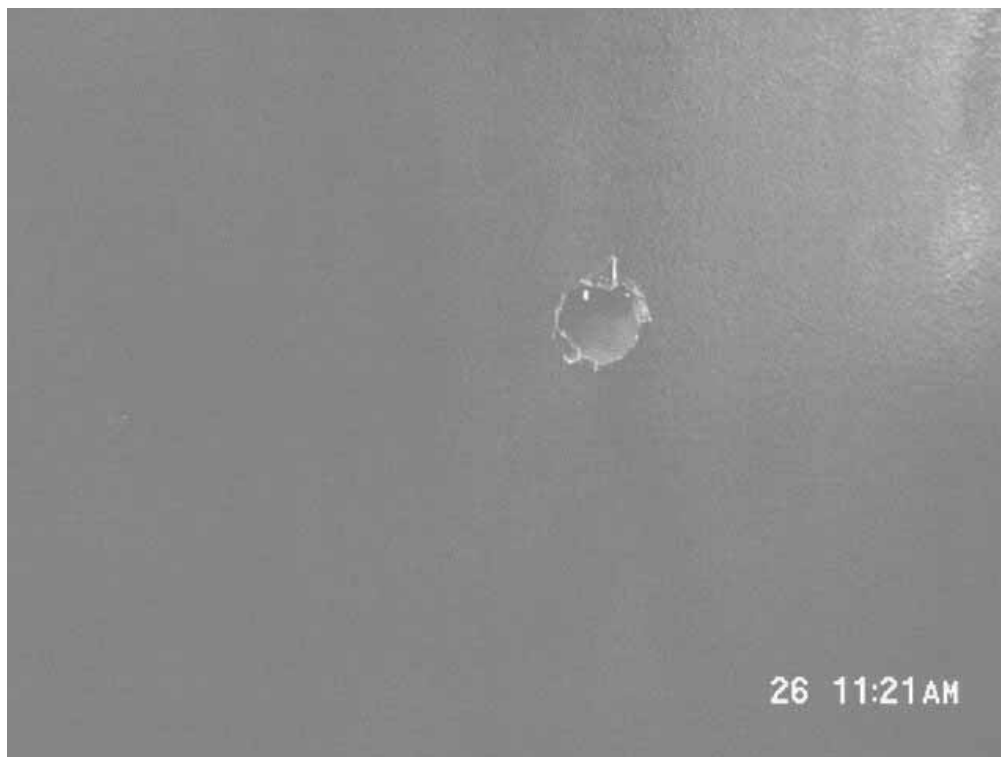
**Welding Operations, Picture Taken Inside Occupied Classroom**

**Picture 7**



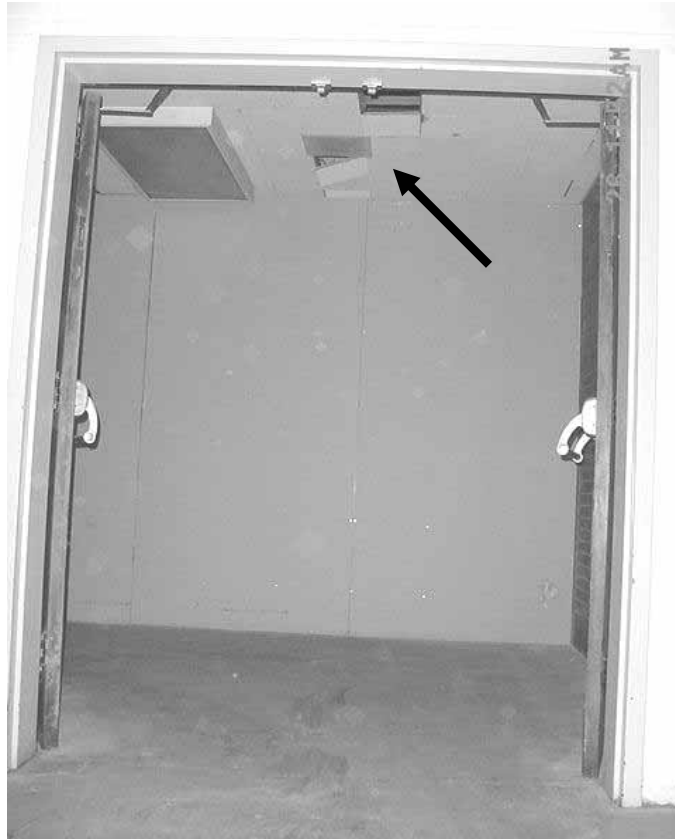
**Plywood Construction Barrier on Second Floor**

**Picture 8**



**Hole in Construction Barrier**

**Picture 9**



**Gypsum Wallboard Construction Barrier on First Floor, Note Missing Ceiling Tiles**

**Picture 10**



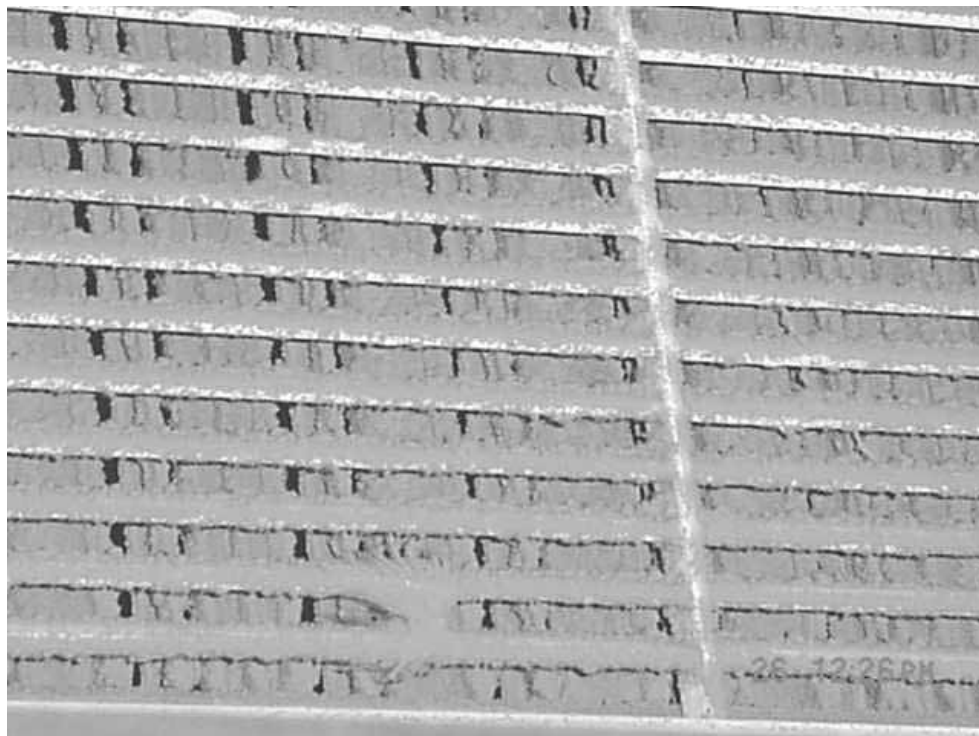
**Fiberglass Insulation/Fiberboard on Exterior of Construction Barrier (Previous Picture), Note Spaces Between Panels**

**Picture 11**



**Dirt, Debris and Construction Vehicles, Picture Taken from Inside Occupied Classroom**

**Picture 12**



**Accumulated Dust on Classroom Exhaust Vent**

TABLE 1

**Indoor Air Test Results – Weymouth High School, Weymouth MA – November 26, 2003**

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultrafine Particulates **1000p/cc <sup>3</sup>	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background	408	ND	ND	24.5-37	39	38					Sunny, scattered clouds, SW winds 5-10 mph, foggy conditions, heavy construction traffic, light street traffic
109	995	ND	ND	14.3	71	33	20	N	Y	Y	Dry erase markers (DEM)
102	1374	ND	ND	17.2	74	29	0	Y	Y	Y	DEM, heat complaints, loose window pane, window/door open, accumulated items
100A	1027	ND	ND	23.9	74	27	10	N	Y	Y	DEM
Construction Barrier (hallway outside old gym entrance)	800	ND	ND	141-232	65	24					Containment wall plywood-spaces around barrier-light penetrating-strong drafts, fiberglass on construction side, holes in plywood barrier
210	1322	1	ND	98.2	68	34	19	Y	Y	Y	Construction vehicles/welding

\* ppm = parts per million parts of air

\*\*1000p/cc<sup>3</sup> = particles per cubic centimeter parts of air**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
 600 - 800 ppm = acceptable  
 > 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

Table 1-1

TABLE 1

**Indoor Air Test Results – Weymouth High School, Weymouth MA – November 26, 2003**

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultrafine Particulates **1000p/cc <sup>3</sup>	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
											operations outside of classroom
211	1290	ND	ND	124	70	31	26	Y	Y	Y	
013	1433	1	ND	62.6	75	30	12	Y	Y	Y	Exhaust blocked by furniture, DEM, CT, MT
016	729	ND	ND	22	79	25	1		Y	Y	
Main Office	899	ND	ND	14.9	76	24	8	Y	Y	Y	
017	952	ND	ND	24.4	67	42	22	Y	Y	Y	Unit exhaust ventilator
019	702	ND	ND	32.6	71	27	1		Y	Y	15 occupants gone 5 min
Kitchen (elementary sch prep)	445	1-2	ND	79.6-103	63	31	2	Y	Y	Y	Construction vehicles oper outside
018	1078	ND	ND	17.1	61	51	18	Y	Y	Y	
Hallway Outside 018				45-50							
014	1364	ND	ND	70.2	74	29	20				

\* ppm = parts per million parts of air

\*\*1000p/cc<sup>3</sup> = particles per cubic centimeter parts of air**Comfort Guidelines**

Carbon Dioxide - < 600 ppm = preferred  
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Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

Table 1-2

TABLE 1

**Indoor Air Test Results – Weymouth High School, Weymouth MA – November 26, 2003**

Location	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	Ultrafine Particulates **1000p/cc <sup>3</sup>	Temp (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Construction Barrier (near ele school kitchen)	491	ND	ND	289	60	31					Hole in GW barrier, MT's-strong drafts

ND = non detect

**Comfort Guidelines**

\* ppm = parts per million parts of air

\*\*1000p/cc<sup>3</sup> = particles per cubic centimeter parts of air

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 1-3